

SPADELLA PIMUKATHAROS, A NEW BENTHIC
CHAETOGNATH FROM SANTA CATALINA
ISLAND, CALIFORNIA

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Abstract.—*Spadella pimukatharos* is described and compared with closely related species *Spadella legazpichessi*, *S. nana*, and *S. schizoptera*. These species are related in part by the structure of the adhesive digital organs. The substratum apparently preferred by *S. pimukatharos* is a sediment rich in fragments of coralline algae.

The genus *Spadella* Langerhans was discussed by Alvarino 1970, 1981b, who summarized the differential characteristics of the species and their world distributions. The species of this genus can be divided into two groups, those with adhesive, digital, hand-shaped organs at the ventral part of the tail segment and those without digital, adhesive organs. Among the species with adhesive digital organs (Alvarino 1981a) are species of two types, which can be divided into two subgroups. In *S. pulchella* Owre, 1963, and *S. hummelincki* Alvarino, 1970, the digital organs are covered by thick tubercular papillae, whereas in *S. schizoptera* Conant, 1895, *S. nana* Owre, 1963, *S. legazpichessi* Alvarino, 1981, and *Spadella pimukatharos*, n. sp., the fingerlike structures are strengthened by thin muscular fibers and each fingertip has a pad of very fine papillae.

The species that are closely related to *Spadella pimukatharos* are *S. schizoptera*, *S. nana*, and *S. legazpichessi*. *Spadella schizoptera* inhabits the Bahamas (Conant 1895), Misaki, Japan (Yosii and Tokioka 1939), New South Wales, Australia (Mawson 1944), Cayos Soldier, Florida (Owre 1963), Cayo Gun, Bahamas (Feigenbaum 1976). The records from Japan and Australia are probably erroneous identifications because populations of species of *Spadella* do not extend over such wide areas; their distributions are limited to directly-con-

nected zones. *Spadella nana* inhabits Cayos Soldier, Florida (Owre 1963), Bahamas (Owre 1972); *S. legazpichessi* was obtained at Enewetak, Marshall Islands (Alvarino 1981a). *Spadella bradshawi* Bieri, 1974, from San Diego, California, lacks the hand-shaped fingerlike adhesive organs.

Spadella pimukatharos, new species
Figs. 1, 2

Material.—Holotype (USNM 99379), 5 paratypes (USNM 99380) collected at Fisherman's Cove, Santa Catalina Island, California, 13 Mar 1985.

Diagnosis.—The descriptions of the anatomical features are based both on mature adult specimens (Stage IV of sexual development), and young specimens at Stages I, II, and III of maturity.

The body is opaque, with well developed muscles on the dorsal and ventral sides. Lateral sides are very narrow. No pigment or pigmentation pattern has been observed, although the specimens were examined with a microscope shortly after preservation. The colleague who collected them did not find the specimens pigmented.

Total length of full mature specimens reached 3.0, 3.5, and 3.75 mm, excluding the tail fin. Specimens measure 1.75, 2.0, and 2.5 to 2.75 mm at I, II, and III stages of maturity, respectively. The stages of ma-

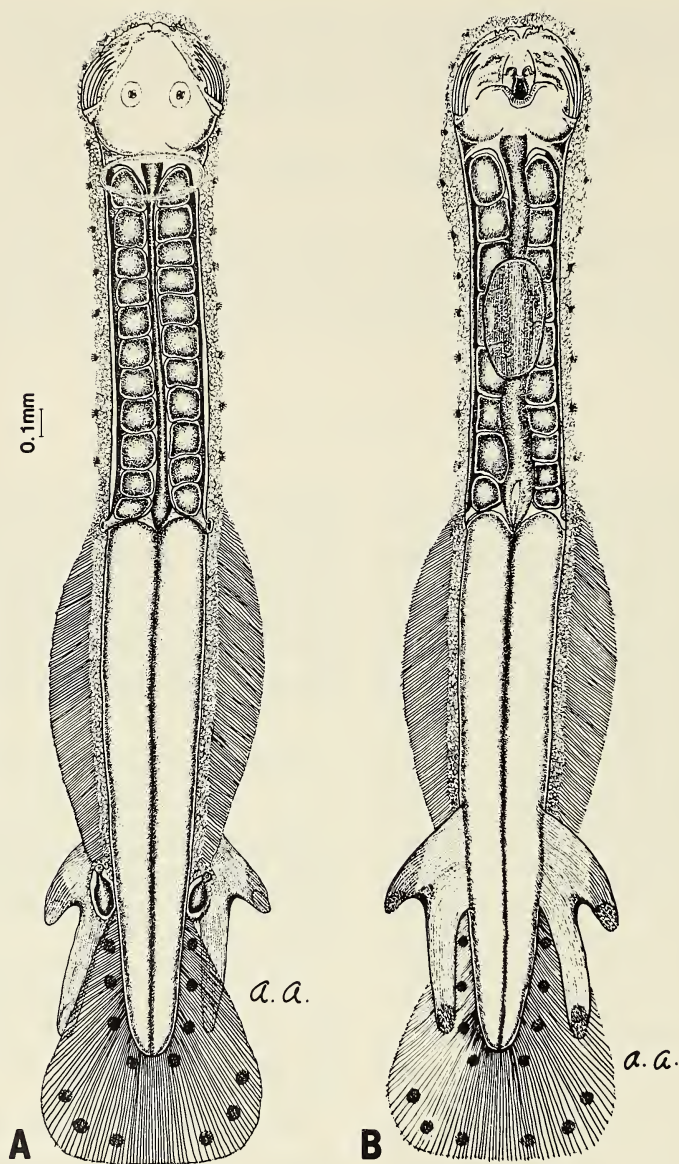


Fig. 1. *Spadella pimukatharos*: A, Dorsal view; B, Ventral view.

turity are based on the development of the gonads, mainly of the ovaries and the ova.

The body is about the same width from head to tail, slightly narrow at the neck and tapering at the end of the tail segment; it widens slightly at the region of the transverse septum that separates the trunk and tail segments.

The head is about as long as wide. Head,

trunk, and tail are thickly covered by col-larete or alveolar tissue, giving the animal the appearance of having the same width from head to tail, except for the tapering at the end of the tail.

The caudal segment makes up 50% of the total length of the animal.

The eyes are large and roundish, placed at the center of the dorsal side of the head,

and are the same distance from each other as from the sides of the head. The pigmented region of the eyes is large and includes 2 branches, the longer branch is parallel to the longitudinal axis of the body, and the short branch extends perpendicularly at midlength from the large branch. The pigment separates 5 small, clear regions filled with lenses: one large region towards the side of the head, 2 small regions toward the center of the head limited by the short and long branches of pigment, and 2 very small regions at the end of the large vertical branch. This general pattern is typical of most chaetognaths.

There are 7–9 hooks at each side of the head. They are thin, curved, and in all examined specimens appeared to be pleated together at the sides of the head. There are 2 to 3 anterior teeth, which are thin, short and pointed. No posterior sets of teeth were observed.

The mouth is on the ventral side, has 2 round pads anterior to it (Fig. 1B).

The corona ciliata, located at the dorsal side of the neck, is ellipse-shaped, with the transverse axis more than twice the length of the vertical axis (Fig. 2A).

The collarete extends as a strong thick stratum, covering the head and extending along the neck, trunk, and tail.

Intestinal diverticula are absent.

The ventral ganglion is large and thick; it is located at about the midlength of the trunk and $\frac{2}{3}$ of the ganglion extends over the anterior part of the trunk while approximately $\frac{1}{3}$ of the ganglion extends over the posterior part of the trunk, being closer to the neck than to the posterior septum. The ganglion does not occupy the total width of the trunk, and it is not as large as in *S. legazpichessi* and most other species of *Spadella*.

The pair of lateral fins extends from the region of the opening of the oviducts to the seminal vesicles. The fins are completely rayed. The caudal fin is long, spatula-shaped, rounded laterally and wider at the tip of the tail segment, and ends with a straight pos-

terior edge. It is independent of the posterior end of the lateral fins. Its origin is anterior to the posterior end of the seminal vesicles. The portion of the tail segment surrounded by the tail fin is about $\frac{1}{3}$ of the tail segment.

The adhesive digital organs, located ventrally at each side of the tail segment in the region of the seminal vesicles, are formed by 2 fingerlike processes, similar to the thumb and index fingers of a human hand, the thumb being broader at the base than the index finger. Both the thumb- and index-like fingers at each side are strengthened by muscle-like fibers. At the ventral part of the tip of each finger is an oval pad of very fine papillae. These adhesive digital structures develop from the ventrolateral sides of the posterior part of the tail segment, and are independent of the lateral and tail fins and seminal vesicles. These digital organs extend ventrally to support the animal far away from the substratum while it is resting or when it is crawling. These organs help to attach the animal to the substratum (Fig. 2D). The fins are used during darting and swimming activities. Both types of behavior, attachment to the substratum and crawling and swimming, have been directly observed in *Spadella* by the author.

The digital structures of young 1.75 mm specimens up to the fully mature 3.75 mm specimens were of the same shape, and had the same number of fingers and structural characteristics. Thus, there is no evidence that the number of digital formations increases with growth in *S. pimukatharos*, as reported by Feigenbaum (1976) for *S. schizoptera*. Probably an increase with growth in the number of fingers in these adhesive organs does not apply to every species of *Spadella*. Also, the increase in the number of fingers Feigenbaum (1976) observed for *S. schizoptera* was due to the material he analyzed, that is, his specimens ranged from larval stage (newborn) to 14-day-olds. It is obvious that in growth from larvae to the phase before Stage I of maturity, some

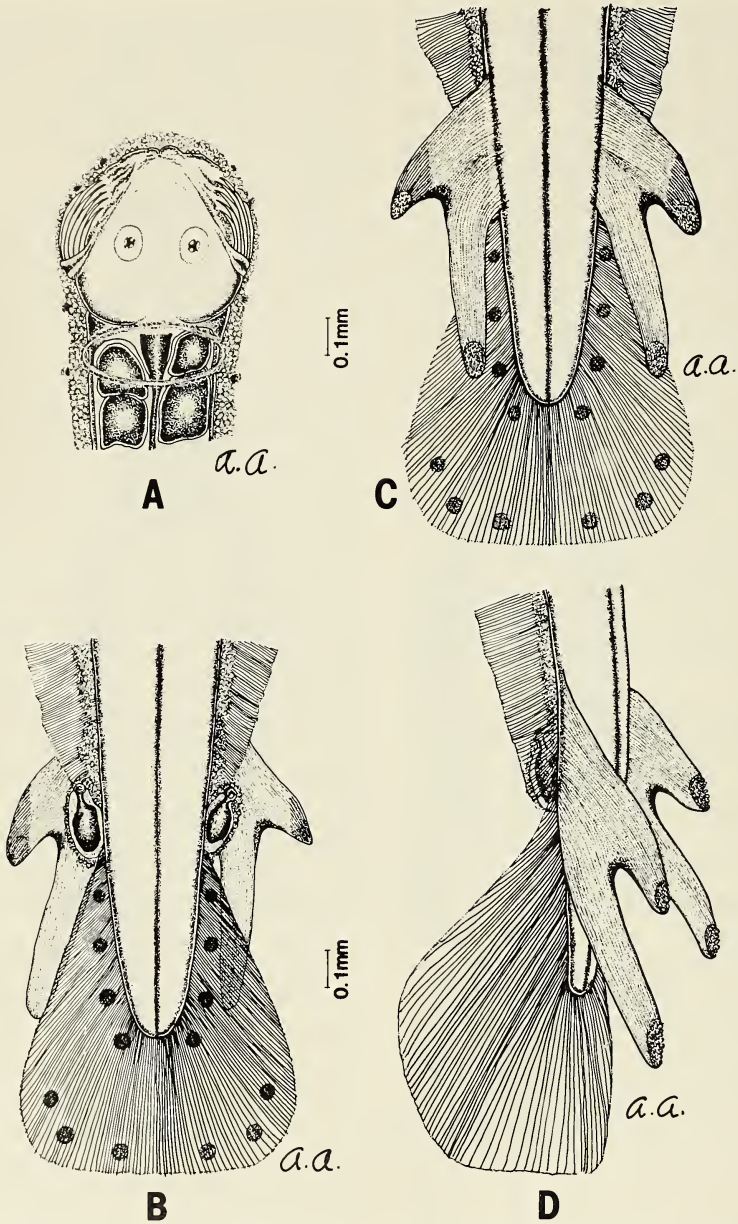


Fig. 2. *Spadella pimukatharos*: A, Dorsal view of head and neck; B, Dorsal view of posterior part of tail segment; C, Ventral view of posterior part of tail segment; D, Right side view of posterior part of tail segment showing dorsolateral position of seminal vesicles, and ventrolateral position of adhesive digital organs.

changes in meristic characteristics will be found, but does not imply that such changes take place during the development from Stage I to fully mature Stage IV.

From the ventral side to the dorsal side

of the animal, the sequence of anatomical structures is: digital organs, tail fin, posterior part of lateral fins, seminal vesicles (Fig. 2D).

The ovaries extend to the neck region and

fill the trunk cavity. The ova are large, hexahedral, with roundish edges and angles. They are pressed together and completely fill the ovaries, which compress the intestine towards the ventral side (Fig. 1A, B).

The oviducts open by cups dorsolaterally. The lateral fins extend ventrally anterior to the opening of the oviducts. The ventral position of the fins and dorsal setting of the oviducts results in an adequate functional device to ensure the transference of sperm during copulation (Fig. 1A).

The seminal vesicles touch both the posterior end of the lateral fins and the anterior end of the caudal fin. Seminal vesicles are protected ventrally by both the posterior and anterior parts of the lateral fins and tail fin. The seminal vesicles are oval, and smaller than in *S. legazpichessi*. The seminal vesicles resemble small amphores without handles, with anterior short neck open at the top of the neck. They are covered by the alveolar collarette tissue (Fig. 2B).

Sensory spots with sensory cilia are distributed over the tail fin and along the edge of the lateral fins and collarette from the head to the posterior part of the trunk. Fourteen of these spots occur on the tail fin, and about 10 appear to be distributed at each side from the head to the region of confluence of collarette and anterior part of lateral fins. More spots extend along the edges of the lateral fins.

Remarks.—*Spadella pimukatharos* differs from *S. schizoptera*, *S. nana*, and *S. legazpichessi* in the general aspect of the body, corona ciliata, hooks, ventral ganglion, shape of ova, shape of seminal vesicles, and shape of the adhesive organs. (See Table 1).

According to Conant (1895), *S. schizoptera* has two pairs of lateral fins, whereas *S. nana*, *S. legazpichessi*, and *S. pimukatharos* have one pair of lateral fins. Owre (1963: 380) indicates regarding *S. schizoptera*, "The specimen from Soldier Key has a single pair of lateral fins which begin 0.14 mm anterior to the transverse septum and terminate in

the adhesive organs"). Owre (1972) referring to *S. schizoptera* explains it as "having 1 (2?) pairs of lateral fins," but unfortunately her illustration of this species does not elucidate this question, since the oviducts are drawn extending over the fins, making it impossible to define whether the lateral fins are one or two pairs. A ventral view of the species will show clearly the particular characteristics of the lateral fins. *Spadella schizoptera* has also been described by Conant (1895) as having intestinal diverticula, which are absent in the other species of *Spadella*.

Distribution.—The specimens of *Spadella pimukatharos* were collected by James (Tony) R. Chess at 10 m depth in 10 cm core samples (coffee cans) at Fisherman's Cove in Santa Catalina Island, California. According to Chess (pers. comm.), the highest number of specimens were obtained from locations where fragments of the coralline algae *Lithothamnion australe* made up more than 50% of the sediment, and at those locations the species occurred in densities of 3566/m², while in finer sediments the species was less abundant, from 127–636/m². Chess (pers. comm.) also indicated that the species was present in all five samples obtained from Fisherman's Cove on 13 Mar 1985.

Chess (pers. comm.) noted that specimens of this species were not found in samples from Fisherman's Cove obtained from 1972 to 1975, and during 1980, 1981, and 1983. However, specimens of *S. pimukatharos* were abundant at Fisherman's Cove during collections of 1984 and 1985.

Thus, it is not clear whether this species is established in this area. Either it is endemic in the region, or the population has been transported by the strong flow of warm waters from the south and has become established incidentally in Santa Catalina Island waters. It should be remembered that the warm climate in the Californian Pacific during 1984 and 1985 was probably related to the strong El Niño conditions of the South Pacific during 1982–1983, although the warmer than normal conditions persist in

Table 1.—Differential characteristics of species of *Spadella* having digital adhesive organs with apical papillar pads.

Character.	Species			
	<i>Spadella schizoptera</i> Conant, 1895	<i>Spadella nana</i> Owre, 1963	<i>Spadella legazpichessi</i> Alvaríño, 1981	<i>Spadella pimukatharos</i> n. sp.
Body length mm	1.9–4.9, wider at level of posterior septum	0.75–2.70	1.8–2.2, trunk strong, opaque, widest at mid- length	1.75–3.73, strong, opaque almost same width from head to tail
Head	Broader than body, narrow neck. 1 pair of pads at mouth	Broader than body. Neck distinct. 1 pair of papillae between anterior teeth and mouth	Large, wider than body. Neck clear- ly distinct	Roundish, same width as trunk. Neck slightly dis- tinct. 1 pair of round pads in front of mouth
Tail segment as % of total length	47.0–53.7	40–50	50	50 or slightly more
Lateral paired fins	2 pairs. Anterior pair extending from level poste- rior to ventral ganglion to open- ing of oviducts. Second pair from this point to seminal vesicles. Only 1 pair of lateral fins (Owre 1963)	1 pair extending from a level an- terior of oviducts to seminal vesi- cles	1 pair extending from level of ovi- ducts to seminal vesicles	1 pair extending from level anterior of opening of ovi- ducts to seminal vesicles
Caudal fin	Long, spatula- shaped	Spatula-shaped, starting at poste- rior end of sem- inal vesicles	Spatula-shaped, starting at poste- rior end of sem- inal vesicles. 12 sensorial spots. No rayless zone	Long, spatula- shaped, starting at level of posterior end of seminal vesicles. No rayless zone
Eyes			Large, oval, pig- ment in longitu- dinal band tilted to sides, and short band per- pendicular at midlength	Large, round, pig- ment in longitu- dinal band crossed by short band pointing to center of head
Hooks	8–11, long curved, sharp pointed	5–9	8–9 at each side, thick, strongly curved	7–9 at each side, thin, curved
Anterior teeth	2–3, long, slender, curved towards midline	1–3, innermost longer than oth- ers, curved to- wards midline	Up to 5 on each side. First 3 lon- ger than others. Third on each side longest. Curved towards ventral side	2–3 on each side, thin, short, pointed
Posterior teeth	None	None	None	None

Table 1.—Continued.

Character.	Species			
	<i>Spadella schizoptera</i> Conant, 1895	<i>Spadella nana</i> Owre, 1963	<i>Spadella legazpichessi</i> Alvarino, 1981	<i>Spadella pimukatharos</i> n. sp.
Corona ciliata	Three-cornered or pear-shaped. Part on head and neck	Variable in shape, extending from neck towards head	Ring-shaped at dorsal part of neck	Elliptical at dorsal side of neck. Transverse axis more than twice length of vertical axis
Ventral ganglion	Large, thick, overlaid by numerous sensory spots	As broad as long	Large, thick, at midlength of trunk. About 50% length of trunk, as close to neck as to posterior septum	Large, thick, at midlength of trunk, extending $\frac{2}{3}$ to anterior part and $\frac{1}{3}$ to posterior part. Closer to neck than to posterior septum. Not covering ventral width
Sensorial spots	Abundant, distributed in longitudinal and transverse rows	Symmetrically arranged in pairs on caudal fin, and longitudinal rows on body	Symmetrically arranged on tail fin (6 on each side). Conspicuous along edge of lateral fins, 6 or more on each lateral edge of collarette	Symmetrically arranged 14 on tail fin, other 10 on each side from head to confluence of collarette with lateral fins. More along edges of lateral fins
Ovaries	Reaching neck or anterior end or midlength of ventral ganglion	Reaching to neck. 2–5 huge ova, pressing intestine into "S" shape	Reaching neck region. Few large ova, pushing intestine into sinuous shape	Reaching neck region. Ova large, hexahedral, packed together, filling ovaries, pressing intestine towards ventral side
Seminal vesicles	Ellipsoidal, reniform, touching both lateral and tail fins	Oval, roundish, anterior to tail fin. Protected ventrally by lateral and tail fins	Ellipsoidal, reniform, touching posterior end of lateral fins and anterior end of tail fin. Open at middle edge towards posterior half of vesicle	Small, oval, amphora- or flask-shaped, anterior thin neck opening dorsally at anterior end
Intestinal diverticula	Present or absent according to various authors	Absent	Absent	Absent
Adhesive digital organs	Hand-shaped, continuation of lateral fins, with 4, 5, 6 fingerlike processes with adhesive papillae	Ventrally from posterior end of lateral fins to seminal vesicles. Divided into 2 stout fingers with muscular fibers	3 long, thin fingers on each organ, not connected to fins, but attached to tail at level of seminal vesicles. Outermost finger	2 fingers on each side, like thumb and index of human hand, strengthened by muscular fibers, with oval pad of

Table 1.—Continued.

Character.	Species			
	<i>Spadella schizoptera</i> Conant, 1895	<i>Spadella nana</i> Owre, 1963	<i>Spadella legazpichessi</i> Alvarino, 1981	<i>Spadella pimukatharos</i> n. sp.
		and papillae or tubercules at tip. First finger longest	longest. Strengthened by thin muscular fibers. Large sensorial club at ventral side of tail	papillae at ventral tip
Collarette	Thick at neck, extending to seminal vesicles	Thick at neck, tapering towards seminal vesicles	Thick at neck, extending along body, tapering at posterior part of tail segment	Strong, covering head and body
Geographic distribution	Bahamas, Florida. Records from Japan (Yosii and Tokioka 1939), and from New South Wales, Australia (Mawson 1944) may be erroneous	Florida	Enewetak (Marshall Islands)	Fisherman's Cove, Santa Catalina Island, California

California up to this date. It is well known from the literature that during El Niño conditions, several populations from tropical eastern Pacific waters have been transported north off the U.S. and Canada, reaching as far north as Alaska. There is no information on the species of *Spadella* inhabiting waters south of San Diego, California. Thus, the question of whether *S. pimukatharos* is endemic to Santa Catalina Island or is transported to this area from a southern source will be elucidated when the populations of *Spadella* inhabiting Mexican and Central American Pacific waters are studied.

Etymology.—The specific name is a combination of "Pimu" and "katharos." Pimu was the original name of Santa Catalina Island until 1542, and *katharos* is the Greek root for Catalina, which means pure, clean, unsullied. This island was discovered in 1542 during the Spanish Expedition under Juan Rodríguez Cabrillo with two vessels, the *San Salvador* and the *Victoria*. He named San Salvador and Victoria the islands now called San Clemente and Santa

Catalina (Instituto Historico de Marina 1943). In 1602, during the Spanish Expedition of Sebastián Vizcaino with three vessels, *San Diego*, *Santo Tomás* and *Tres Reyes Magos*, the islands were named San Clemente and Santa Catalina (Instituto Histórico de Marina 1944). The original name of San Clemente was Limun (Instituto Histórico de Marina 1943). Both Rodríguez Cabrillo and Vizcaino indicate in their diaries of navigation that Santa Catalina, San Clemente, and the Channel Islands were inhabited by native Indians of California. Pimu, Pimuna, Pimun-gen apparently also meant "People of the Sea," and the Spaniards used to call these indians Pipimar and Pipimares (Kroeber 1925). According to Rodríguez Cabrillo and Sebastián Vizcaino, the indigens fed mainly on fish, and sardines were very abundant.

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Literature Cited

- Alvariño, A. 1970. A new species of *Spadella* (benthic Chaetognatha).—*Studies on the fauna of Curaçao and other Caribbean islands* 24:75–89.
- . 1981a. *Spadella legazpichessi*, a new benthic chaetognath from Enewetak, Marshall Islands.—*Proceedings of the Biological Society of Washington* 92(1):107–121.
- . 1981b. Benthic Chaetognatha. Study and distribution (Los quetognatos bentónicos. Estudio y distribución).—*Memorias VIII Congreso Latino-Americano de Zoología, Fauna Marina* 2: 1109–1127.
- Bieri, R. 1974. A new species of *Spadella* (Chaetognatha) from California.—*Publications of the Seto Marine Biological Laboratory* 21(3–4):281–286.
- Conant, F. S. 1895. Description of two new Chaetognaths (*Spadella schizoptera*) and *Sagitta hispida*.—*Johns Hopkins University Circular* 14(119):77–78.
- Feigenbaum, D. L. 1976. Development of the adhesive organ in *Spadella schizoptera* (Chaetognatha) with comments on growth and pigmentation.—*Bulletin of Marine Science* 26(4):600–603.
- Instituto Histórico de la Marina. 1943. *Diario de navegación de Juan Rodríguez Cabrillo, 1542.*—*Colección de diarios y relaciones para la historia de los viajes y descubrimientos* 1:27–42. Consejo Superior de Investigaciones Científicas, Spain.
- . 1944. *Diario de navegación del General Sebastián Vizcaíno, en 1602–1603.*—*Colección de diarios y relaciones para la historia de los viajes y descubrimientos* 4:39–68. Consejo Superior de Investigaciones Científicas, Spain.
- Kroeber, A. L. 1925. *Handbook of the Indians of California.* Scholarly Press, Saint Clair Shores, Michigan, 995 pp.
- Mawson, P. M. 1944. Some species of the Chaetognath genus *Spadella* from New South Wales.—*Transactions of the Royal Society of South Australia* 68(2):327–333.
- Owre, H. B. 1963. The genus *Spadella* (Chaetognatha) in the western North Atlantic Ocean, with descriptions of two new species.—*Bulletin of Marine Science of the Gulf and Caribbean* 13(3): 378–390.
- . 1972. Marine biological investigations in the Bahamas. 18. The genus *Spadella* and other Chaetognatha.—*Sarsia* 49:49–58.
- Yosii, N., and T. Tokioka. 1939. Notes on Japanese *Spadella* (Chaetognatha).—*Annotationes Zoologicae Japonenses* 18(4):267–273.

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